Novel Approaches for the Reclaim and Reuse of Power Plant Effluents

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Contractor: University of Southern California
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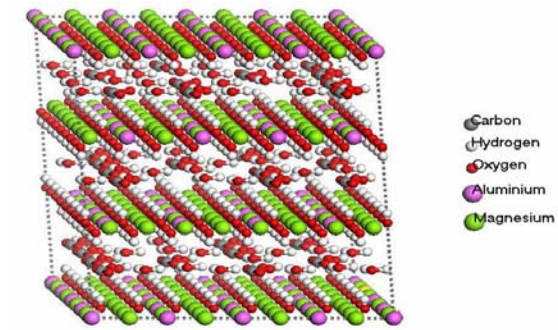

Figure 1. This computer-generated image depicts the layered double hydroxide (LDH) adsorbent tested in this project. The LDH proved effective in removing heavy metals from "model" utility effluent.

The Issue

Power plant cooling systems can account for as much as 95% of a facility's water use,[1] requiring up to five million gallons of water a day.[2] With growing competition for the state's water supplies, brought on by an average population increase of approximately 600,000 people a year and other factors, power plant managers are exploring the use of reclaimed water.

Reclaiming and reusing the water from other power plant processes is an obvious solution; however, some operational, environmental, and health issues need to be addressed to ensure that such use is viable and safe. From an operational standpoint, it is important to understand reclaimed water's contribution to scaling (mineral deposits that increase operation and maintenance costs).

From an environmental and health perspective, it is important to identify the levels of heavy metals in the reclaimed water and to develop methods for removing them. By doing so, plants can protect the health of both their workers and the aquatic environments into which this water is discharged.

In particular, research needs to examine the fate of trace amounts of arsenic (As) and selenium (Se) in reclaimed water. Most flue gas scrubber wastewater and boiler blowdown, for example, contain these metals, but those streams are classified as high-volume, "too clean to clean" sources (i.e., the contaminant levels are very low). Conventional approaches are not capable of dealing economically with such dilute concentrations of these metals. Even so, questions of exposure and legally allowable limits of these metals in discharge water require that they be removed and disposed of safely.

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1. Maulbetsch, John S., *Comparison of Alternate Cooling Technologies for California Power Plants,* California Energy Commission, 500-02-079F, 2002.

2. California Energy Commission, *Environmental Performance Report of California's Electric Generation Facilities,* P700-01-001, July 2001, p. 28.

Project Description

PIER-EA funded the University of Southern California's Chemical Engineering Department to investigate the use of a new adsorbent material to remove heavy metals from utility wastewaters.

First, the research team characterized the arsenic (As) and selenium (Se) concentrations in effluent samples (boiler blowdown and cooling water) from two local power plants, using inductively coupled plasma mass spectrometry. Based on these findings as well as previous studies,[3] they created "model" power plant effluent containing As and Se in concentrations ranging from 20 ppb to 200 ppb. They then used this model effluent in both batch and flow experiments to test the effectiveness of an anionic clay material in adsorbing (and thus removing) As and Se from the effluent, thereby "cleaning" the wastewater.

The proprietary adsorbent material—a layered double hydroxide (LDH)—was provided by Media Process Technology, Inc. Researchers tested both calcined (heat-treated/dried) and uncalcined (untreated) versions of the LDH.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Providing environmentally sound electricity.** The adsorbent materials tested in this project may facilitate the reuse of power plant effluents, thereby reducing the amount of fresh water needed for cooling system operation, while helping to ensure that trace metals are reduced to environmentally acceptable levels.
- **Reducing California's water consumption.** Reclamation and reuse of power plant effluents decreases utility demand for fresh water.

Results

Boiler blowdown and cooling water discharges contained low levels of arsenic and selenium, usually less than 50 parts per billion (ppb).

Batch and flow experiments showed the LDH adsorbents to be highly effective in removing As and Se from such effluents, with equally good or higher adsorption capacities and faster uptake rates than reported in the literature for other materials. The calcined LDH showed higher adsorption capacity and efficiency than the uncalcined LDH for both As and Se; equilibrium for the 20-ppb solutions was obtained within the first two hours of adsorption. Adsorption increased with increasing temperature, indicating an overall endothermic process. The starting solution pH did not significantly influence the adsorption of As and Se on calcined LDH, as long as it was higher than 4.

Several anionic solutions were shown capable of regenerating the spent adsorbents—i.e., removing the adsorbed As and Se so the LDH could be reused. Phosphate was particularly effective in removing both As and Se. However, new LDH material is currently less expensive

3. Steinberger, A., and E. D. Stein, "Characteristics of Effluents from Power Plant Generating Stations in the Southern California Bight in 2000" in S. Weisberg and D. Elmore (eds.), *Southern California Coastal Water Research Project Annual Report 2004*, Westminster, California.

than disposal options for the desorption solutions. If LDH regeneration is desired, cost-effective means must be investigated for environmentally sound disposal of the desorption solutions.

The Toxicity Characteristic Leaching Procedure (TCLP) showed the LDH adsorbents to be safe for disposal (As at 0.32 ppm and Se at 0.18 ppm). Field studies are needed to confirm LDH stability in the potentially acidic environments of landfills.

In conclusion, the calcined LDH adsorbents show promise for treating utility effluents so they can be reused in power plants, thus enabling significant water savings.

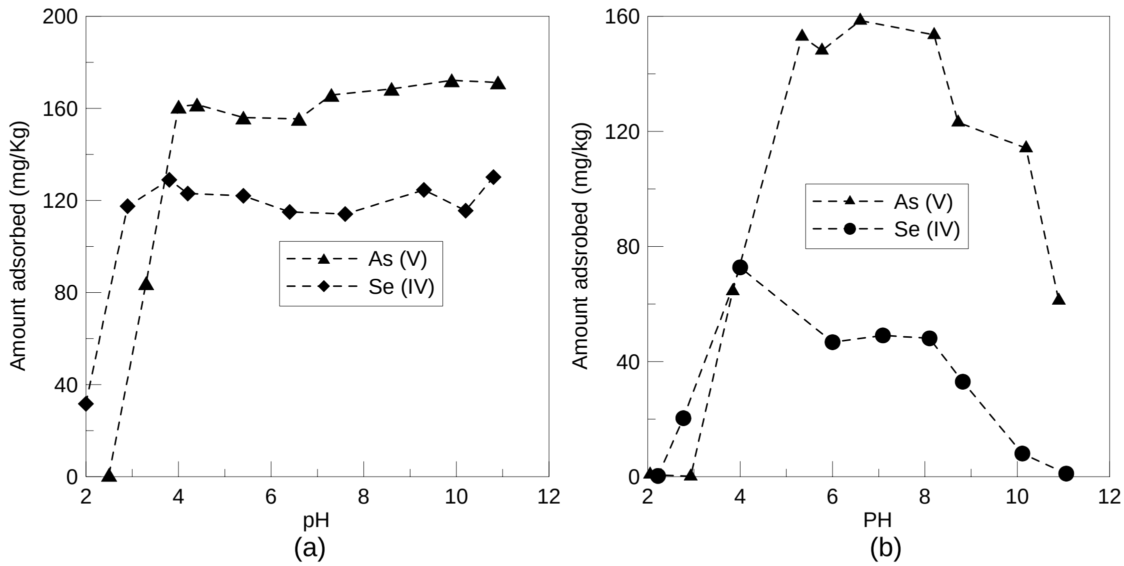

Figure 2. The effects of pH on the uptake of As (V) and Se (IV) in 20-ppb solutions on (a) calcined and (b) uncalcined LDH

Final Report

The final report for this project will be available in August 2005 and will be posted at http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-125.html.

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